The Efficacy of Structured Field Trip Programs for Third Grade Students at the Center of Science and Industry

A Senior Honors Thesis

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Introduction

"Teach me and I will forget. Show me and I may remember. Involve me and I will understand" (An ancient Chinese proverb, cited in Jakubowski, 2003 p.24). As this quotation implies, student involvement in learning is especially important to me. I am currently studying to become an early elementary school teacher and I feel that active learning is the best route to student understanding. I have learned in several classes about Jean Piaget and Lev Vygotsky and their focus on the importance of social constructivism and scaffolding in education. These ideas have led me to believe that students will learn the best when they are active participants in their education, rather than sponges that soak up information provided by their teachers. As a future teacher, I want to ensure my students have access to all types of resources that will help them achieve. I believe that field trips can provide experiences students cannot have in a classroom. Not only do they provide students with additional hands-on learning opportunities, but they also prove to children that learning takes place outside the classroom as well as within it. I do realize, however, that not all field trips contribute to students' learning. As a researcher, I wanted to help determine whether or not field trips can enhance student knowledge.

In the fall of 2002, the Center of Science and Industry (COSI) launched a new program called Learning Expeditions. These Learning Expeditions are structured field trip programs that provide students and teachers with a scavenger hunt, teacher's guide, and classroom activities to help supplement their visit to COSI. Using grant money from the Ingram-White Castle Foundation, COSI set out to achieve two goals.

The first goal was to increase access to COSI for students from Columbus Public Schools. The second goal was to assess the efficacy of the Learning Expeditions.

Background

Following President George W. Bush signing into law the “No Child Left Behind (NCLB) Act” in 2002, many schools have seen a shift toward standardized testing and a focus on reading and math. In order for 95% of students to pass the standardized tests so that a school can meet its Adequate Yearly Progress, which is one of the NCLB stipulations (Department of Education, 2003), teachers must place extra emphasis on these areas to promote success, leaving little time for field trips and other supplemental activities. Good field trips, however, can help students connect real-world experiences with what they are learning in the classroom and enhance their understanding. As the opening quotation suggests, in order to learn their best, students should be engaged in the material and construct their own knowledge (McLoughlin 2004). According to Smith-Sebasto & Cavern (2006),

> the literature on misconceptions in science shows that both children and adults hold ideas of their own for concepts about which they have little experience or knowledge… multiple studies have shown that classroom instruction is often not sufficient to induce students to change their naive ideas about a subject… however, when allowed to explore the phenomenon for themselves in hands-on experiences, students often accept and assimilate new knowledge and experience into their conception of it (p. 14).

It is therefore imperative that students are active participants in their own learning so they can fully understand all the concepts that school and society require they know. For example, field trips are a way to make a meaningful connection to their curriculum, as demonstrations or objects they encounter are real-life applications of what they have been learning in class (Kisiel, 2006).

In their 2006 study, Smith-Sebasto & Cavern studied a group of 169 seventh grade students who attended a residential environmental education program at the New Jersey School of Conservation (NJSOC). The aim of the program was to develop environmental knowledge in its participants and instill values that would help resolve environmental problems. As part of the study, they looked at what effect participation in the program had on students' attitudes toward the environment, as well as the effect of pre- and post-trip activities on the ability of the NJSOC program to improve students' attitudes about the environment. All of the students in this study attended the NJSOC program and were divided into four groups. One group did not receive pre- or post-trip activities, one group received only pre-trip activities, one group only received post-trip activities and the final group received both pre- and post-trip activities. Participants were given three environment-related attitude assessments before and after they attended the program.

From the study, researchers found that the only group that had a statistically significant increase in positive attitudes from their previous assessment scores was the group that received both pre- and post-trip activities. They determined that "the combination of both the pretrip and posttrip activities with the NJSOC program resulted in a change in students' fundamental respect for the environment" (p. 14). Although their sample size was small, this study is a basis for more research on whether multiple activities coinciding with a particular science program can influence students' attitudes about the subject they are studying.

Other researchers (Cox, Marsh, Kisiel & Melber, 2003) conducted a study at a natural history museum in order to determine how the content was communicated to the students, what the students gained, and how the tour aligned with recommendations from both science standards and informal learning literature. They found that most tours were lecture-oriented, the focus was on facts instead of larger concepts, the vocabulary was often too complex for students to understand, and few open-ended questions were asked. The researchers also found that the tours provided few connections between the museum content and students' prior knowledge. After the tours, students were asked about what they learned, and the vast majority (91%) had responses that showed low to medium levels of learning based on the researchers' coding scale. The low-level responses were mainly "unrelated facts or descriptions" (p. 208), while medium-level responses included accurate details and some discussion about what they learned. The few who reported high levels of learning integrated concepts and details of what students learned. In addition, 92% of all the students who participated said they enjoyed going through the museum with a guide and more than 51% of students stated that they learned a lot of new things. This study also found that these tours did not align with previous literature about field trips stating that learners should be involved and make personal connections to the new material.

In addition to including their version of an alternative tour, the researchers include pedagogical elements that they believe should be incorporated into guided tours to enhance student learning. These aspects are:

1. Incorporate orientation and signals that focus visitors' attention, suggest how to approach a museum, or how to make effective use of the museum as a learning opportunity.
2. Integrate learning tools for the use of visitors - notebooks, clipboards, measuring devices, prompt sheets, and pictures.
3. Provide learning cues related to overarching concepts or what to pay attention to.
4. Incorporate opportunities for active learning – hands-on exploration of objects and cooperative social experiences.
5. Include labels or cues that prompt students to connect exhibit content with home and school.
6. Provide labels or cues that provide scaffolding of learning to correspond with the age of the visitor.
7. Develop mechanisms that draw on strengths of the diversity of students with special attention to students from non-English language backgrounds and students with disabilities. (p. 214)

Cox et al. (2003) believe that these strategies can help make connections between students' personal lives, the science content standards, school curriculum, and students' inquiries.

Another study (Tenenbaum, Rappolt-Schlichtmann & Zanger, 2004) was designed to investigate kindergarten students who, in addition to their classroom curriculum, visited a local children's museum. At the start of their study, researchers interviewed each student about his or her concepts regarding buoyancy, bubbles and currents, as well as attitudes about science. The experimental group visited the science exhibits in the museum, while the control group visited social studies exhibits. In the science exhibits, the experimental group interacted with staff members who asked questions, engaged in a discussion, or gave a brief presentation before letting the students experiment with their own materials.

After the museum visits, researchers returned to the classroom to conduct post-tests. They found that students who participated in the science museum activities demonstrated more content knowledge and understood more complex concepts than those who went to the social studies exhibits. While these children knew more about bubbles, currents, and why objects sank or floated, they were no more likely than their control-group peers to correctly identify whether an object would sink or float. The study cites that the children's learning increased because the teachers and museum staff created experiences within the students' zone of proximal development and modeled appropriate strategies. Interestingly, "the docents did not explain scientific concepts to children. Instead, they supported children in their development of explanations" (p. 54). Supporting children in developing their own explanations, as well as question-asking, encourages children to construct their knowledge and become more engaged with the material. Although attitudes toward science did not increase, both teacher and researcher observations concluded that the children enjoyed going to the museum. The researchers attribute the lack of change to the fact that "young children do not differentiate science from other school topics" (p. 55) and suggest that future research include questions about how much children enjoy activities that are specifically related to science.

In her article about informal learning environments, Linda Ramey-Gassert (1997) explains that while in-school learning tends to be disconnected from real-world experiences and reliant on symbols, out-of-school learning allows learners to gain greater meaning through completing intellectual or physical tasks using real objects. The informal environments also tend to be more social, open-ended, learner-centered, and non-evaluative than school science programs. With regard to field trips, she states that students learn more when they are prepared, when they believe there is information to be learned on the field trip, and when they have control over their learning. In addition, science museums provide equitable learning environments that “emphasize the use of cross-gender skills” (p. 440), therefore enhancing all students’ science knowledge.

While Ramey-Gassert (1997) focuses on the positive aspects of informal learning environments, Guisasola, Morentin & Zuza (2005) point out that when using this type of environment, teachers tend to establish general or limited learning objectives, and there is usually little preparation, despite existing literature highlighting a positive correlation between preparation and student learning. In their article, they describe a museum visit by students to a science museum in San Sebastian, Spain, adhering to the materials the researchers designed. Before these students went to the museum, the class read and discussed articles about electricity and magnets, two of the concepts they would see at the museum. The teacher also explained what they would see at the museum as well as some ideas they should remember while they were there. A third component of the preparation asked students to imagine they were in the museum at certain exhibits. They were then told to hypothesize about the objects, answering questions such as “what would happen if you let the solid metal disc [from the *Magnetic brake* model] drop” (p. 547)? This encourages students to apply their existing knowledge to the situations they are about to observe.

During the visit, students divided themselves into workgroups and explored the exhibits. The teacher visited each group to see what the students were doing and asked them questions persuading them to dig deeper into the information at each exhibit. After the visit, the class returned to the discussions they had before visiting the museum and used notes the students took at the museum to answer questions about science concepts. The researchers found that the use of educational materials allowed for more student learning during the science museum visit.

Supplementing the classroom experience with field trips may be especially important to those students who are not achieving success in the classroom or whose families do not have the resources to provide outside learning activities. According to its 2005-2006 district report card, Columbus Public Schools are on Academic Watch, and meet only five of the twenty-five state indicators. Additionally, 73.9% of its students are considered economically disadvantaged (Ohio Department of Education [ODE], 2007). Since it costs $7.50 per child and $13.50 per adult to attend the COSI exhibits, many families in the area simply cannot afford to visit the museum. Students taking field trips with their classes must also pay an additional fee for transportation which, combined with admission cost, may be too costly for some families to pay.

Nonetheless, field trips to COSI can provide these students with concrete examples of what they are learning in the classroom, as well as many other science topics. Seeing experiments first-hand can not only spark a child's interest and motivate them to learn more, it will also help them fully understand why things happen. Using money from the Ingram-White Castle Foundation grant, COSI was able to provide reduced-cost admission for students and cover transportation costs for all groups that participated in the Learning Expeditions as part of this project, including many students who without this opportunity may never have been able to see what COSI has to offer.

According to Summers (2004), many museums offer classes that align with state and federal learning standards. She mentions that “taking advantage of these classes also helps justify the field trip to administrators who may consider such trips as a sacrifice of instructional time” (p. 28). The Ohio Department of Education (ODE) has academic content standards that each student must meet before graduation, and has also created benchmarks so parents and educators know what students should be learning in each grade. The physical science portion of the third-grade benchmarks includes forces and motion (ODE, 2006). The Learning Expeditions that the students in this study embarked upon include an exhibit about Forces and Motion. Teachers were told to specifically visit this exhibit in addition to any others they chose, as it relates directly to the third-grade science curriculum that includes a unit about forces and motion. Students can therefore learn the content standards through the exhibit and the field trip could be less likely to be viewed as a waste of instructional time.

Method

Participants

The participants of this study include students who were in third grade during the 2005-2006 school year and attended elementary schools in the Columbus Public School System. A total of 678 pre-tests from 13 different schools, and 382 post-tests from 10 different schools were received (see Appendix A for a complete list of participating schools). One of the schools submitted pre-tests but not post-tests, and four schools submitted post-tests but not pre-tests. Furthermore, one school submitted more post-tests than it did pre-tests, and another only provided post-tests from a small portion of the students who took the pre-tests. These seven schools were subsequently eliminated from the data analysis. Our updated data included 407 pre-tests and 315 post-tests from the seven remaining schools. Their teachers were also included in the study. Each teacher received a “teacher survey” asking about internet access in relation to educational materials, comfort in both teaching science and bringing classes to COSI, as well as asking which, if any, of the force and motion activities provided by COSI were used in the classroom prior to the field trip. Five teachers returned the survey and only two of these were from schools that were part of the final data. Since they did not use the classroom activities, a correlation between the activities COSI provided and any improvement of student scores cannot be made. After the initial study, a focus group was conducted with four of the third-grade teachers, all from different elementary schools, who participated in the Learning Expeditions project. Chaperones were present during the field trip but were not surveyed.

Treatment

Fliers were sent to Columbus Public elementary schools via email (see Appendix B) inviting teachers to participate. When teachers made field trip reservations, COSI mailed them a packet containing information about the Learning Expedition. In addition to the pre-visit tests, teachers received a letter describing the project, suggestions for specific exhibits relating to force and motion, questions to ask at these exhibits, and pre- or post-visit force and motion lessons (see Appendix C). Teachers were told to administer the pre-visit tests one to three days before visiting COSI and either mail them to COSI or bring them on the day of their field trip. After visiting COSI, students took a post-test that contained the same science-based questions as the pre-test. Following the conclusion of the study, researchers held a teacher focus group to discuss how COSI can better serve students and teachers, how field trips can be improved, the teachers' definitions of a "successful" field trip, as well as general feelings regarding COSI and its services.

Instrument

The pre- and post-visit tests that the students took were comprised of six science-based questions about force and motion, two and four (respectively) attitude-based questions, and one open-ended question about science. The science-based questions were exactly the same on both tests, however the post-test was in a different order than the pre-test (see Appendix D for both pre- and post-tests). The six questions were nicknamed "Ball" question, "Rocket" question, and "Wall" question for analysis purposes. The "Ball" questions have a picture of a ball rolling down a hill, the "Rocket" questions are about a bottle rocket, and the "Wall" questions involve throwing a baseball at a wall. These questions align directly with the third grade physical science benchmarks that ODE (2006) provides as part of its content standards. The following chart describes with which benchmark indicator(s) each question aligns. The questions appear in the order they are found on the pre-test.

Question	Benchmark Indicator(s) Met	Indicator Descriptions
“Ball”	1	Describe an object’s position by locating it relative to another object or the background.
“Rocket”	2	Describe an object’s motion by tracing and measuring its position over time
	3	Identify contact/noncontact forces that affect motion of an object (e.g., gravity, magnetism and collision)
“Wall”	2	Describe an object’s motion by tracing and measuring its position over time
	4	Predict the changes when an object experiences a force (e.g., a push or pull, weight and friction).

Table 1: Benchmark indicators

These questions also correspond to the specific exhibits relating to force and motion that teachers were instructed to visit during their field trips. Both the “Ball” and “Wall” questions relate to the Gadgets exhibit. The “Wall” questions relate more specifically to the Ball Wall within the Gadgets exhibit. The “Rocket” questions coincide with the Bottle Rocket demonstration in the Space exhibit.

Analysis

Science-based Questions

In order to analyze the science-based questions, answers were coded on a 0-2 scale depending on the answer given by the student. The “rocket” multiple choice question was worth one point, while questions that asked students to draw and/or describe what was happening were worth two points. Open-ended answers were coded as follows:

Score	Criteria
2	Correctly answered question
1	Partially correct answer; missing a fundamental concept
0	Incorrect answer or no answer given

Table 2: Coding criteria

In order to earn full points on the “Ball” questions, students had to write that the balls were in different locations *and* make a reference to movement. The “Rocket” question required that they mention the change in direction and that the rocket stops briefly before falling down, and the “Wall” question required that the ball first hit the wall, then bounce either to the floor or back to the hand.

Attitude-based Questions

To analyze these questions, pre-test answers were compared to the answers on the post-test for the same question. Questions from the post-test that began with “After visiting COSI…” were analyzed separately. Attitude questions first asked how students felt about science in general. The next question asked more specifically about science class.

Open-ended Questions

Since the open-ended questions could be answered with either words or a picture, the most common answers were categorized for comparison. Most responses fit into categories, while others did not appear frequently enough to have their own category or contained pictures that were unclear. Other answers included pictures or comments referencing a previous question in the test, indicating that the student did not understand what the question was asking. The pre-test answer categories for “Draw or explain your favorite science lesson” were

- Animals (included bugs, insects, butterflies)
- Experiments (included beakers, test tubes, chemicals, mixing)
- Fossils
- Gravity
- Magnets
- Plants
- Rocks

The post-test answers to the prompt “Write something new that you learned about science while visiting COSI” were placed into the categories

- Balloons
- Explosions
- Force
- Gravity
- Motion
- Science is fun

Responses that did not fit into these categories included references to specific exhibits as well as those that, like the pre-test, were illegible or unclear.

Results

A total of 407 pre-tests and 315 post-tests from seven different schools were included and analyzed as part of the final data set.

Science-based Questions

The questions involving science concepts produced mixed results. Fully correct answers to the “Rocket” and “Wall” questions increased from pre-test to post-test, while fully correct answers to the “Ball” questions decreased (Appendix E has a complete breakdown of scores for all categories).

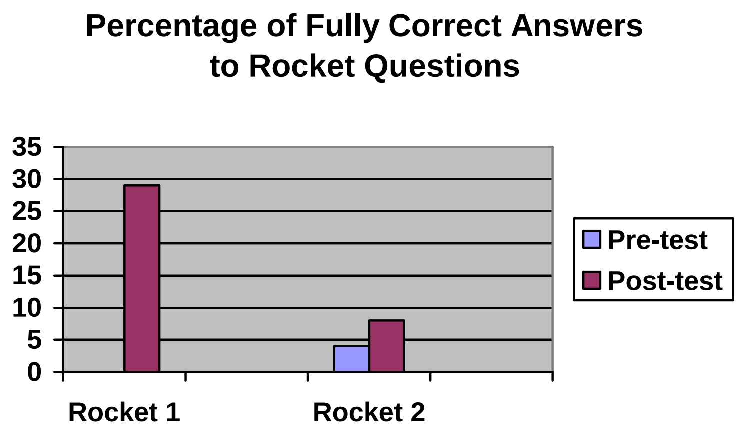

Chart 1: Fully correct answers to rocket questions

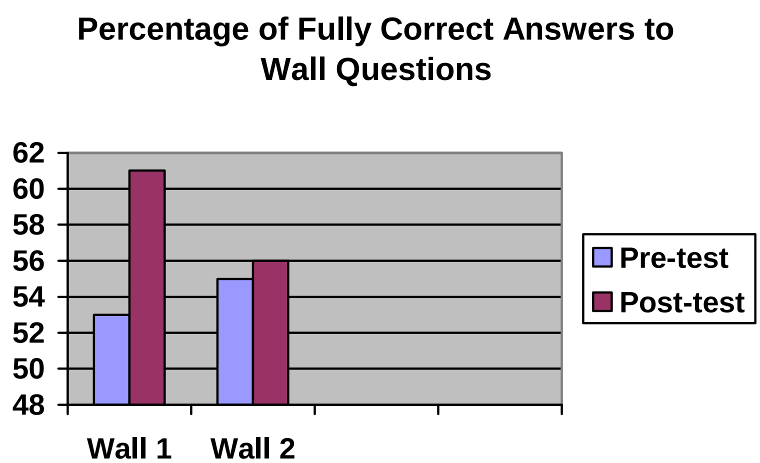

Chart 2: Fully correct answers to wall questions

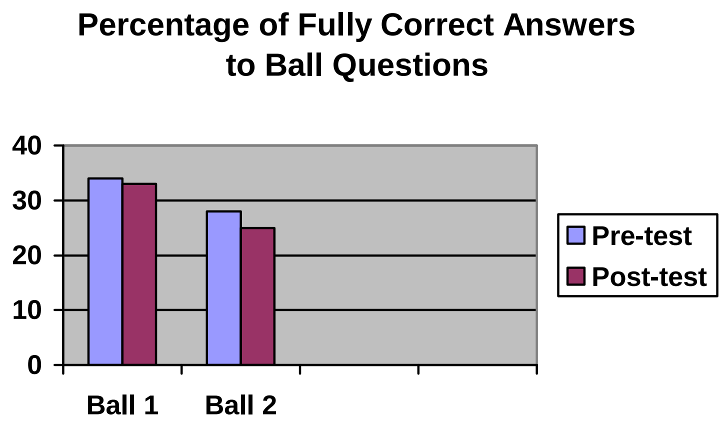

Chart 3: Fully correct answers to ball questions

It is interesting to note that on the pre-test, many students thought the rocket moved the slowest just before hitting the ground, citing that if it did not slow down the "astronaut" they believed to be inside would crash and get hurt. This type of answer appeared less frequently on the post-test, and the percentage of students identifying the correct answer increased by 29%. Fully correct responses for the explanation portion of the "Rocket" question doubled from pre- to post-test. For the first wall question, in which the students drew a picture of what happens when a ball is thrown at a wall, fully correct answers increased by 8%. The explanation portion, however, only increased by 1%. Although the fully correct responses to the "Ball" questions decreased slightly on the post-tests, the proportion of partially correct responses to the second ball question did increase. This question is more complex than the first, in that it requires the student to determine which of two pictures occurred first as well as explain their reasoning. Doing this involves reflection on *why* the pictures are different as opposed to simply *how* they are different.

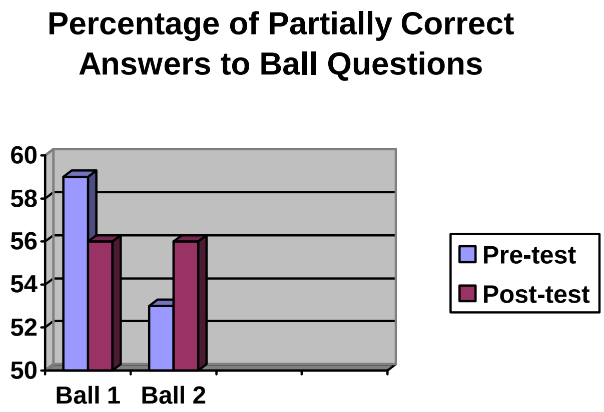

Chart 4: Partially correct answers to ball questions

Attitude-based Questions

Changes in attitudes toward science were even more positive than the outcomes of the science-based questions. Not only did the percentage of students who thought science was “easy” or “interesting” increase, but the percentage of those responding that science was “hard” or “boring” decreased.

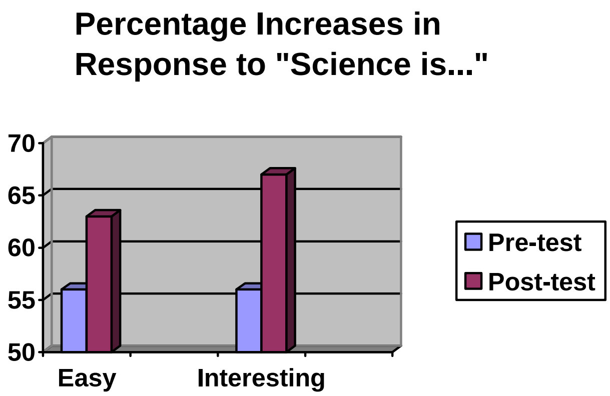

Chart 5: Positive attitude increases

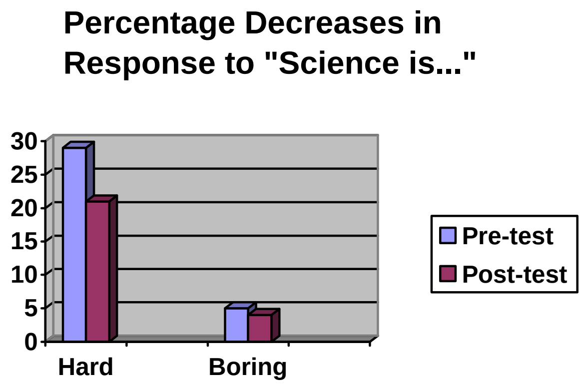

Chart 6: Negative attitude decreases

Although the negative attitudes only decreased slightly, the positive attitudes increased considerably, especially the idea that science is interesting. Coinciding with this, the majority of respondents answered that after visiting COSI, they feel science is more interesting and more fun than they previously believed.

Open-ended Questions

Of the 363 students who answered the question, the most common response for "draw or explain your favorite science lesson" was rocks (see Table 3 for percentage breakdown). One student said,

> "My favorite is when we talk about rocks and fossils. I think rocks are cool. I like when I get to [bring] some of my collection to show the class."

Many students mentioned experiments they do in class (including chemicals, mixing, and pictures of beakers or test tubes), including one who wrote

"When you mix chemicals together and look how it changes. I love mixing chemicals."

Other common responses referred to fossils, gravity, meal worms, magnets and animals. There were a variety of other responses mentioning lessons that did not fall under the aforementioned categories. One student even said,

> "I think they are all great because in every one of those science projects you learn different things. I can't choose just one!"

Category	**Number of Responses**	**Percent Of Total**
Animals	17	4%
Experiments	39	11%
Fossils	7	2%
Gravity	7	2%
Magnets	7	2%
Meal Worms	15	4%
Rocks	50	14%

Table 3: Common pre-test categories

Of the 272 students who answered the post-test question "write something new you learned about science while visiting COSI," the most common response was that science is fun (Table 4 shows percentages for each category). One student wrote,

> "I learned that science can be fun and next time we have science I'm going to think about how fun science can be and I'm going to think about COSI."

Another said,

> "COSI was fun and I was so happy to go to COSI and it was fun."

Many students wrote about the explosions they saw during the science show. Thirteen percent said they learned more about force, including one who declared,

> "I learned that force and motion [were] cool at first I thought it would be boring but I was wrong,"

and another said,

> "I learned about force and motion if I blow a marble and it rolls I force it to roll."

Gravity and motion were also commonly mentioned. Other answers referred to specific exhibits such as

> "… Bowling balls are less weight in space," and,
>
> "Babies have long cords to eat while in the stomach."

These responses show that while their scores may not have increased, children did take something meaningful from their visit.

Category	**Number of Responses**	**Percent of Total**
Balloons	11	4%
Explosions	38	14%
Force	34	13%
Gravity	21	10%
Science is fun	41	15%

Table 4: Common post-test categories

Teacher Focus Group

During the discussion with four teachers, the greatest concern they raised was that the teachers and schools need more facilitation during their field trips to COSI. More specifically, the teachers would like to see a liaison at COSI that can help them plan and carry out field trips. The liaison would assist teachers by letting them know what COSI has to offer, decoding COSI language (i.e., some don't know what "Rat Basketball" is unless they have previously visited and seen it), and provide information before the class' arrival. These liaisons could also help plan a schedule for the field trips by making an "a la carte" menu so that the teachers can choose which exhibits they would like to visit. Increased communication in this area could also help align what the students are learning in the classroom with COSI exhibits, therefore resulting in increased learning while on the field trip. Several teachers mentioned that they are often unsure exactly which exhibits students visited, since most students are separated into groups and led by chaperones. They felt that a more structured field trip with a schedule, or at least a list of exhibits to visit, would ensure that students would go to those areas that relate to Columbus Public School curriculum.

In addition to not knowing which exhibits chaperones visit with their groups, teachers raised the concerns that many chaperones do not have a strong scientific knowledge base. Therefore, they are mostly in attendance to monitor behavior rather than facilitate the learning experience. We discussed possibly sending home materials to review before the field trip, including a DVD showing specific exhibits and informing the chaperones about the science behind them. The teachers thought this would be a good idea, but mentioned that at times they do not know how many chaperones will actually come until the day of the field trip, and many meet them at the site, which would prevent the possibility of having a "training session" before they leave the school. One idea to circumvent this dilemma was to assign trained staff members to lead small groups around COSI, highlighting the science concepts. One teacher thought it would be a good idea for the staff member to spend about ten minutes explaining the exhibit and the scientific ideas behind it, then let the children explore and build their own meaning for about twenty minutes before moving on to the next exhibit. Teachers also mentioned that reading is often a barrier, not only to students but to other adults who may visit COSI and are unable to read, or, who do not have a strong enough science background to fully comprehend the material. Having staff members as guides throughout the field trip would ensure that the students are getting the important facts.

One teacher also mentioned that field trips could be structured more like COSI on Wheels, a traveling program that comes to school sites and provides an assembly as well as hands-on science activities for students. She said that COSI on Wheels does a great job of giving students the “big picture” so they can relate to the concepts. She felt that sometimes going to each exhibit at COSI is like opening a book in the middle, without reading the introduction or the beginning. Students often do not understand the concepts because they do not have a framework in which to fit the information. Another teacher suggested having a staff member lead a whole group presentation that tells the students about the big picture so that they can more readily understand each exhibit. One teacher said the students always have a lot of fun on field trips to COSI, and with a little more structure it could also be an even more meaningful learning experience.

Limitations

Because all the respondents to this study were third-grade students in Columbus Public Schools and because they were not randomly selected, the study is not representative of the third-grade population. Furthermore, it is not necessarily representative of Columbus Public Schools third graders because the teachers decided whether or not to attend and participate. Since the tests were anonymous, we could not look at attributes such as sex, socioeconomic status or race. All of these factors could have influenced the outcome of the study. For example, we had a high response rate from Kenwood Alternative Elementary School, a French-immersion school. Since most students do not attend language immersion schools, the proportion of the population who does may be overrepresented. We also had a relatively small sample size. Initial problems with the program included teachers not receiving their packets before the visit, as well as not providing the pre- and/or post-tests as asked.

A major limitation in this study was the teachers. Not only did very few of them complete and return the teacher survey, many expressed to the researchers that the activities they were asked to complete was too much work. One teacher became irate with one of the researchers, yelling that she felt it was ridiculous that she was being asked to give her students the pre-tests when she had so much else to do during the day. Unfortunately, so few classes were submitting their pre-tests that we eventually had to tell them we would not pay for the reduced-cost admission or their transportation unless we had the pre-tests when they arrived. This resulted in an increased proportion of pre-tests that were submitted toward the end of the study. Had all students who attended the field trips completed pre- and post-tests and had those tests been given to the researchers, our results could have been more conclusive.

Discussion

Although the results of this study are not as conclusive as hoped, COSI did achieve its first goal. During the course of the project 2,384 Columbus Public Schools students were admitted to the museum with reduced-price admission. The remaining portion of their admission as well as all transportation costs were covered by grant money from the Ingram-White Castle Foundation.

Without both experimental and control groups, we cannot contribute any rise in student achievement on the science questions of the post-tests to the experiences students had at COSI. On the other hand, it is inspiring to see that the percentage of the correct answers to some of the science-based questions increased after visiting the museum. Because only two teachers from the final data set turned in their teacher surveys, compounded with the fact that they did not use the pre- or post-visit activities provided in their information packet, we cannot make a correlation between specific activities we provided and student achievement. Had both pre- and post-visit activities been implemented by the teachers as the literature suggests, perhaps we would have seen an even greater increase in correct post-test answers.

If nothing else, student attitude improved after participating in the field trip program. Two-thirds of respondents felt that science was more interesting than they thought before visiting COSI and almost two-thirds felt that COSI made them feel that science was more fun then they previously thought. Students also felt that science seemed easier after their field trip. Positive attitudes about a subject can not only lead to greater interest in it, but also greater self-efficacy which, in turn, could yield higher achievement in science subjects. The participants’ responses to the open-ended questions revealed that they enjoyed their COSI visit in addition to learning about different science concepts.

The teacher focus group provided a great deal of insight into both teachers' and students' needs while visiting COSI. Although it may not be feasible due to budget restrictions, the suggestion of trained staff members assigned to small groups to explain the "big ideas" behind each exhibit before student exploration is supported by literature on student learning. With the help of these docents, students could gain the necessary science background to understand the science concepts, which currently exists in the form of signs. Reading and understanding the signs, one teacher mentioned, could be a barrier for both students and adults.

Recommendations

If I was going to repeat this study I would make several changes. First and foremost, I would stress to the teachers the importance of submitting the pre- and post-visit tests. To help alleviate this problem, I would send an Education Intern from COSI into each classroom to administer the tests and collect them. Without completing the pre-tests, COSI could simply not pay for the field trip. Toward the end of the study this is what COSI did and the response rates increased. The post-tests should also be completed before leaving COSI and collected by either the Education Intern or another staff member who is directly involved in the project.

Another way to improve this study would be for the Intern to lead the force and motion activities provided by COSI. This would also allow for more control in that we could examine which classes participated in specific activities to see if students learned from some more than others. After the visit, the Intern should return to do follow-up activities which, while they would not affect the post-test scores, have been shown by other researchers (Smith-Sebasto & Cavern, 2006) to increase students' learning and understanding.

Conclusion

To conclude, the results of this study are very encouraging. Although not all of the post-test scores were higher than those of the pre-test, many were. A positive attitude toward science also increased for many students, and hundreds of students realized science was fun. More research should be done at COSI, including the use of experimental and control groups, to learn which activities specifically contribute to higher levels of student learning.

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Appendix A
List of Participating Schools

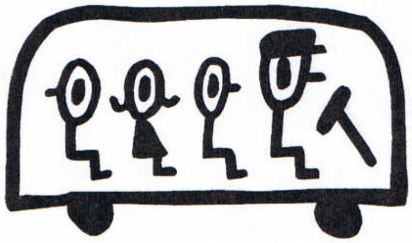
COSI Columbus
Reservation Arrivals

		Students	Teachers	Chaperones
Gables Elementary School	ILS-IWC	40	3	2
Highland Elementary School	ILS-IWC	58	0	8
East Pilgrim Elementary School	ILS-IWC	50	0	5
Easthaven Elementary School	ILS-IWC	42	2	8
Brentnell Elementary School	ILS-IWC	43	7	11
Koebel Elementary School	ILS-IWC	36	2	2
Windsor Alternative Academy	ILS-IWC	50	3	2
Leawood Elementary School	ILS-IWC	51	0	7
Reeb Elementary School	ILS-IWC	70	10	8
Indianola Elementary School	ILS-IWC	65	3	11
Avalon Elementary School	ILS-IWC	74	4	15
Cranbrook Elementary School	ILS-IWC	37	2	8
Beatty Park Elementary School	ILS-IWC	11	2	4
Southwood Elementary School	ILS-IWC	53	2	5
Clinton Elementary School	ILS-IWC	47	4	10
Douglas Alternative Elementary School	ILS-IWC	45	2	6
Fair Arts Impact Alternative Elementary	ILS-IWC	44	4	6
Ecole Kenwood Alternative Elementary School	ILS-IWC	46	2	9
Olde Orchard Elementary School	ILS-IWC	60	3	10
Fairmoor Elementary School	ILS-IWC	68	3	15
East Linden Elementary School	ILS-IWC	33	4	4
Binns Elementary School	ILS-IWC	46	2	9
Berwick Alternative Elementary School	ILS-IWC	52	2	10
Innis Elementary School	ILS-IWC	55	4	6
Deshler Elementary School	ILS-IWC	60	0	15
Cedarwood Alternative Elementary	ILS-	72	3	12

School	IWC			
Hamilton Alternative Elementary School	ILS-IWC	28	4	4
Parkmoor Elementary School	ILS-IWC	109	5	22
Duxberry Park Elementary School	ILS-IWC	30	0	6
Windsor Alternative Academy	ILS-IWC	34	2	6
Siebert Elementary School	ILS-IWC	46	5	6
Fifth Avenue Alternative Elementary School	ILS-IWC	43	6	0
Literature Based At Hubbard	ILS-IWC	19	2	3
East Pilgrim Elementary School	ILS-IWC	55	3	11
West Mound Elementary School	ILS-IWC	61	5	9
West Broad Elementary School	ILS-IWC	73	5	4
Woodcrest Elementary School	ILS-IWC	52	2	4
Liberty Elementary School	ILS-IWC	89	4	20
Fairwood Alternative Elementary School	ILS-IWC	74	8	14
Arlington Park Elementary School	ILS-IWC	64	3	12
Devonshire Elementary School	ILS-IWC	78	3	16
Salem Elementary School	ILS-IWC	51	5	5
Heyl Elementary School	ILS-IWC	47	5	4
Medary Elementary School	ILS-IWC	35	0	8
Monroe Alternative Middle School	ILS-IWC	88	0	15
	Total	2384	140	377

Appendix B
Promotional Flyer

See following page.



A Special FIELD TRIP OPPORTUNITY For CPS 3rd Grade Students & Teachers

Extend your students' understanding of force & motion with a visit to COSI.

Thanks to support from the Ingram-White Castle Foundation, all 3rd graders in Columbus Public Schools have the opportunity to visit COSI for just $1.50 each. That's $5.50 less than regular group admission prices. To make your visit even more affordable, we'll pay for your bus.

Teachers registering for this special field trip will RECEIVE:

- **FREE transportation**
- **Pre– and post-visit materials that tie to your curriculum**
- **Free 45-minute workshop at COSI for their students**

Teachers will be asked to:

- **Administer pre– and post-program assessments to students**
- **Complete a survey after the fieldtrip**

RESERVE YOUR FIELD TRIP TODAY by e-mailing cpscosi@mail.cosi.org or by calling 614.228.COSI and speak to any representative.
To receive this price, you must mention CPS-3 when making your reservation.

Questions? Email cpscosi@mail.cosi.org.

Book now before all available slots for this special discount are taken.

Reservations must be made one month prior to the field trip date.

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Columbus, OH 43215
Phone 614.228.COSI | Fax 614.629.3150

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Appendix C
Force & Motion Activities Guide

See following pages.

COSI Structured Field Trip
Force & Motion

COSI can be an overwhelming place to a primary grade student, with many different exhibits that demand their attention. Your students will want to see and explore everything. To foster an understanding of force and motion in your primary grade students, we suggest the following:

1. Before coming to COSI, consider doing one or more pre-visit lessons (either from those provided by COSI in this packet, or from your CPS curriculum) with your students that tie to the content to your curriculum.

2. Create a field trip schedule for your students. Emphasize two exhibition areas, Gadgets and Space, which include many exhibits that relate to force & motion.

3. While in these exhibition areas, station yourself at the following two exhibits and ask your chaperones to bring each group of students to you for a few minutes:

   Gadgets "Ball Wall" Exhibit and Space"Bottle Rocket" Exhibit

   During your brief interaction with your students at these exhibits, use the guide on the following page to reinforce the main concept of the exhibit while synthesizing your students' learning.

4. When you return to the classroom, follow up with one or more post-visit lessons that tie the content to the curriculum.

Background information on Force & Motion:

When students observe force they usually describe it using terms such as "pushing" and "pulling." These are words that describe how each student uses a contact force to move an object. There are also non-contact forces that move objects such as gravity and magnets.

Although position alone is not enough by itself to indicate a force, students may describe a force based on position of the object since the position can be changed by a contact force; push up or pull down. Force = mass x acceleration. Position helps us measure the rate of acceleration which is one component of force.

During their visit to COSI, encourage chaperones to reinforce, and students to be aware of, the following concepts:

- Position is the location of an object
- To describe an object's position. You can compare it to the position of other objects.
- An object is in motion while it changes position

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Exhibit Guide

Ball Wall (Gadgets):

In the far right corner of Gadgets, behind the Gadgets Café, is the Ball Wall Exhibit. At one end is a launcher. Place a plastic ball in the funnel at the top of the launcher, wind the crank, and send the ball flying to the wall. If the ball hits the wall, the ball will glide down a number of different gadgets and land on a track that students can manipulate.

Questions to ask students at the Ball Wall:

1. What is pushing the ball out of the launcher? (Air triggers a lever, like a catapult.) What is moving the ball down the ramps? (Gravity.)
2. Describe what happens to the ball after it is launched. (The ball comes out of the launcher and flies toward the wall. If it makes it to the wall, it then goes down the ramps from the top to the bottom. If it doesn't make it to the wall, it flies to a certain point, arcs down, and then hits the ground.)
3. When do you think the ball was moving the fastest? (Flying through the air.) When was it moving the slowest? (In the instant it hits the wall it drastically changes movement from horizontal to vertical movement, affected by gravity.)

Bottle Rocket (Space):

Upon exiting the black hole entrance, walk to the right of the Space exhibit and find a 2 liter pop bottle attached to a pole. "Fuel up" a rocket by charging a projectile with compressed air. Students can countdown and observe the release of the miniature rocket, then watch it arc 25 feet up to the ceiling.

Questions to ask students at the Bottle Rocket:

1. Describe what happens when the bottle rocket is launched. (The bottle goes up the pole, stops at the top, and then comes back down.)
2. When do you think the bottle rocket was moving the fastest? (On the way up.) When was it moving the slowest? (In the instant it gets to the top it stops moving.)
3. What pulls the bottle rocket back down to the launcher? (Gravity.)

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Pre- or Post-Visit Lessons

To connect your classroom curriculum to your field trip experience, complete one or more of these lessons, or another lesson from your CPS Force & Motion curriculum, before and after your visit. Reinforce the questions that you asked students at the exhibit to insure they understand.

Move the Marble

PS-2 Describe an object's motion by tracing and measuring its position over time.

Materials: Each student will need: 1 piece of pipe or tubing (6" – 20" in length).
For the piece of pipe or tubing, foam pipe insulation tubing cut in half works well, as does pre-cut pieces of pipe used for household plumbing, and cardboard mailing, paper towel or toilet paper tubes.

The group will need 1 marble and space to move about freely.

The Challenge:

Give each student a piece of pipe or tubing.
Explain that the students, working together, need to pass a marble through the pieces of pipe or tubing from point A to point B in the classroom. Once they get started, they cannot touch the marble. The marble must pass through everyone's piece of pipe or tubing the same number of times. If the students drop it, they must start over.

What do you think?

Describe the movement of the marble? How did you communicate this to the rest of your group?

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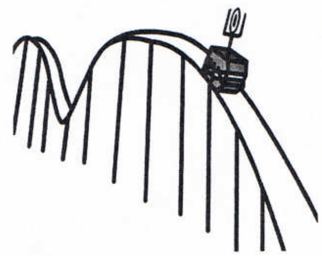
Roller Coaster

PS-2 Describe an object's motion by tracing and measuring its position over time.

Materials: For each group you will need:
1 piece of foam pipe insulation tubing (at least 18" long),
1 roll of masking tape,
1 marble
1 small cup



The Challenge:

Using the foam pipe insulation tubing and masking tape, build a roller coaster with at least 3 hills using the materials provided. Roll the marble through the roller coaster and catch it at the end of the run with the small cup.

For an extra challenge, add a loop.

Things to talk about:

Describe the movement of the marble through your roller coaster. How can you get the marble to go faster?
Have you ever ridden a roller coaster? How did it feel?
Would you do it again (or would you do it if you haven't)?
Why or why not?

The Ultimate Marble Mover!

PS-2 Describe an object's motion by tracing and measuring its position over time.

Materials: Be creative. You will need items that represent all the simple machines, including inclined planes, gears, pulleys, levers, screw, wedge, wheel and axle.
Supplies could include cardboard tubes, plastic pipes, foil, bottle openers, popsicle sticks, balloons, string, foil, foam core, cardboard boxes of various sizes, scissors, egg beaters, can openers, packing peanuts, bubble wrap, hand drills, pulleys, rope, wheels of various sizes, washers, nails, Velcro, duct tape, masking tape, dowel rods, screw drivers, paper plates, etc.

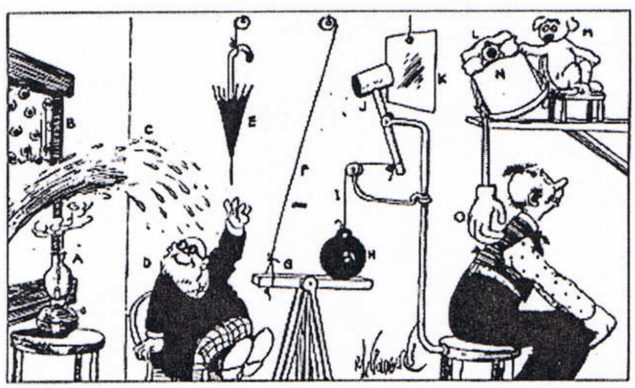
Student Challenge: Working in groups, encourage students to use what they know about gravity and motion, to make something that will move a marble 10 feet (or some other specified distance) on its own. Once they set the marble in motion, they cannot touch it. Test and revise your design as needed.

For example, students might want to make a ramp from a cardboard tube, or a catapult out of a clothes hanger or put the marble in a blown up balloon and attach the balloon to a string and move it, or use the pulleys and a basket to move it.

After each group completes their individual marble mover, connect all the marble movers to see if the class can move the marble around the classroom.

Assessment: Draw or write about the movement of your marble. Draw or write about the process your group used to create your Ultimate Marble Mover.

An Automatic Back Scratcher



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Move a Mini Marshmallow

PS-2 Describe an object's motion by tracing and measuring its position over time.

Materials: Each student will need a plastic spoon and a mini marshmallow

Student Challenge: Give each student a plastic spoon to be used as a marshmallow launcher. Show the students the target. Give them a moment to consider how they could use the plastic spoon as a marshmallow launcher. There are two rules: You must launch the marshmallow with the spoon I've given you (not your hand) and the spoon must be touching your desk (you can't use it like a bat).

Remind students to be careful when launching their marshmallow, they should not hit another student with their marshmallow or their spoon.

Provide each student with a marshmallow that they shouldn't eat (if they eat it, they can't participate). If you'd like to use the marshmallows for multiple launches, use a marker to write the initials of each student on their marshmallow (for identification purposes)

Give students a couple minutes to get ready. On the count of 3, all children should launch their marshmallow.

If you'd like, put on goggles and have the students launch the marshmallows at you. Use a bucket to try and catch the marshmallows as they come at you.
After all marshmallows are launched, have a couple students gather all the marshmallows and place them in a bucket for later use.

Assessment: Have students draw or write about the movement of their marshmallow.

Take this a step further by challenging the students to build a device that will launch their marshmallow the farthest. Provide each group of students with the same materials, including:
2 3 x 5 index cards
3 large paper clips
10 craft or Popsicle sticks
10 rubber bands of various sizes
5 coffee stirrers
2 straws
1 plastic spoon
1 12 inch piece of string
1 pair of scissors
1 metric ruler
1 roll of tape
1 bottle of glue

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Appendix D
Pre-Visit & Post-Visit Surveys

See following pages.

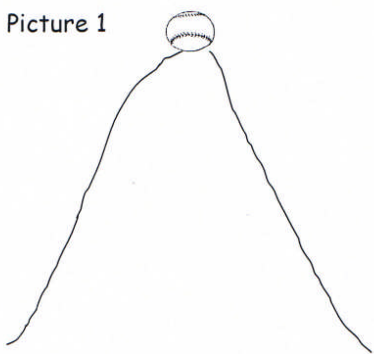
COSI Pre-Survey

School: ____________________ Teacher: __________________________ Today's Date: ________

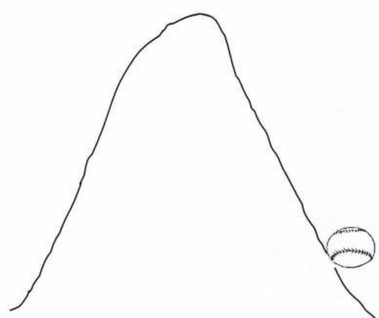
Your school is part of a special COSI program. Before your visit, we would like you to answer some questions. Answer the questions the best you can. Your teacher will not grade you.

Look at the two pictures.

Picture 1



Picture 2



1. How are the pictures different?

____

____

____

2. Which is the "before" picture? Which is the "after" picture? Why?

____

____

____

____

3. A model rocket goes straight up into the air 50 feet, stops, and falls back to the ground. When was it moving the slowest?

B. At 50 Feet

A. Just after the rocket launches

C. Just before the rocket hits the ground

----

4. Draw or explain your answer.

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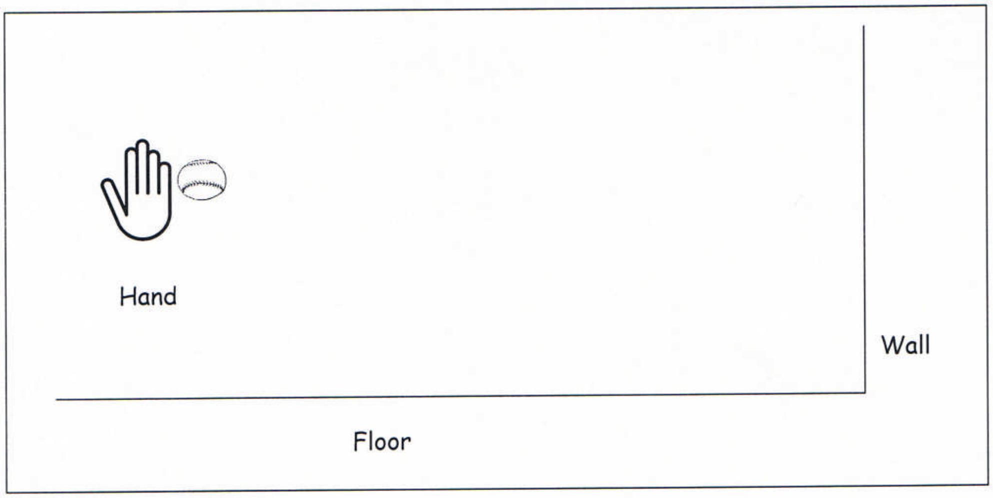
5. Draw lines to show what happens when a baseball leaves your hand and hits a wall.



6. Explain your answer.____

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Tell us what you think . . . .

7. I think science is:
_ Interesting
_ Boring
_ O. K.

8. I think science class is:
_ Hard
_ Easy

9. Draw or explain your favorite science lesson.

____

____

____

____

____

Thanks!

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COSI Post-Survey

School: ____________________ Teacher: __________________________ Today's Date: ________

Your school is part of a special COSI program. After your visit, we would like you to answer some questions. Answer the questions the best you can. Your teacher will not grade you.

1. A model rocket goes straight up into the air 50 feet, stops, and falls back to the ground. When was it moving the slowest?

B. At 50 feet

A. Just after the rocket launches

C. Just before the rocket hits the ground

2. Draw or explain your answer.____

____

____

____

____

____

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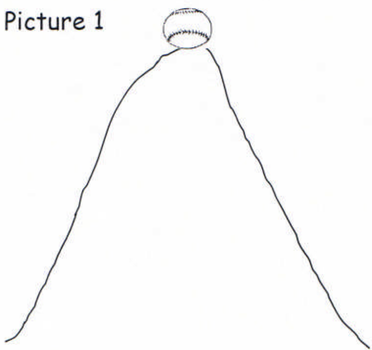
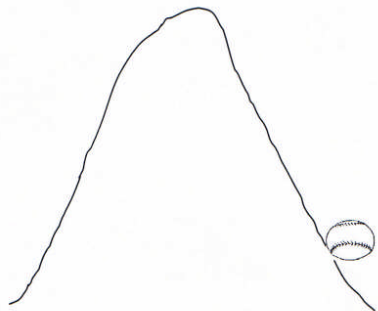
Look at the two pictures.

Picture 1



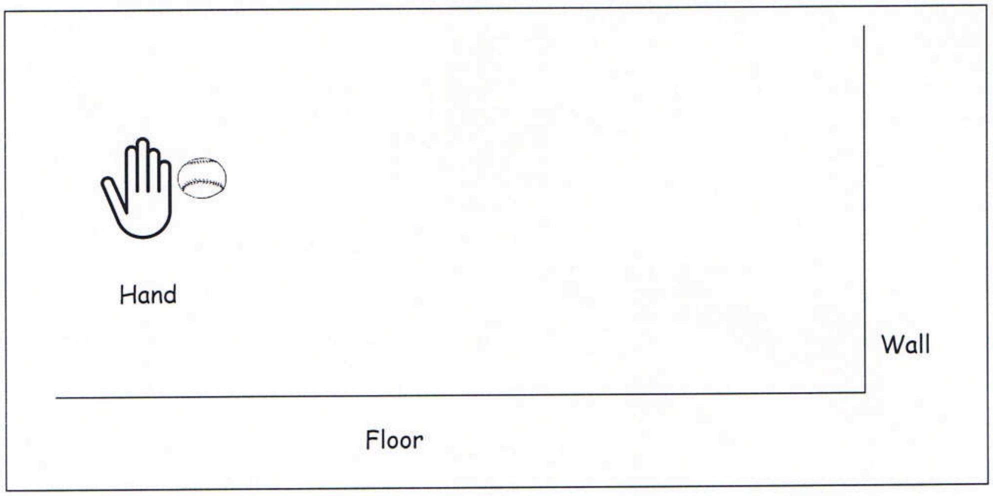
Picture 2



3. How are the pictures different?

4. Which is the "before" picture? Which is the "after" picture? Why?

5. Draw lines to show what happens when a baseball leaves your hand and hits a wall.



6. Explain your answer.____

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Tell us what you think . . . .

7.After visiting COSI, I think science is:
_ More interesting than I thought before
_ Less interesting than I thought before
_ Just as interesting as I thought before

8.Visiting COSI made me feel that science is:
_ More fun than I thought before
_ Less fun than I thought before
_ Just as much fun as I thought before

9. I think science is:
_ Interesting
_ Boring
_ O. K.

10. I think science class is:
_ Hard
_ Easy

11. Write something new that you learned about science while visiting COSI.

____

____

____

____

____

Thanks!

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Appendix E
Student Pre/Post Descriptive Statistics

STUDENT PRE-VISIT TESTS - Selected Schools

School:	Count
Arlington Park	56
East Pilgrim	37
Kenwood	41
Liberty	93
West Broad	74
West Mound	59
Woodcrest	47

Q1 Ball 1 - How are the pictures different?

	Code	Count	Percentage
Correct	2	138	34%
Partially correct	1	239	59%
Incorrect/no answer	0	30	7%
		407	

Q2 Ball 2 - Which is the "before" picture? Which is the "after" picture? Why?

	Code	Count	Percentage
Correct	2	114	28%
Partially correct	1	215	53%
Incorrect/no answer	0	78	19%
		407	

Q3 Rocket 1 - A model rocket goes straight up into the air 50 feet, stops, and falls back to the ground. When was it moving the slowest?

	Code	Count	Percentage
Correct	2	0	0%
Partially correct	1	77	19%
Incorrect/no answer	0	330	81%
		407	

Q4 Rocket 2 - Draw or explain your answer.

	Code	Count	Percentage
Correct	2	18	4%
Partially correct	1	16	4%
Incorrect/no answer	0	373	92%
		407	

Q5 Wall 1 - Draw lines to show what happens when a baseball leaves your hand and hits a wall.

	Code	Count	Percentage
Correct	2	217	53%
Partially correct	1	96	24%
Incorrect/no answer	0	94	23%
		407	

Q6 Wall 2 - Explain your answer.

	Code	Count	Percentage
Correct	2	224	55%
Partially correct	1	40	10%
Incorrect/no answer	0	143	35%
		407	

Q7 I think science is:

	Code	Count	Percetage
Interesting	I	226	56%
Boring	B	19	5%
O.K.	O	119	29%
(no answer)	X	33	8%
(all other responses)	other	10	2%
		407	

Q8 I think science class is:

	Code		
Hard	H	120	29%
Easy	E	229	56%
(no answer)	X	34	8%
(all other responses)	other	24	6%
		407	

STUDENTS POST-VISIT TEST - Selected Schools

School:

	Count
Arlington Park	52
East Pilgrim	37
Kenwood	29
Liberty	59
West Broad	44
West Mound	52
Woodcrest	42

Q1 Rocket 1 - A model rocket goes straight up into the air 50 feet, stops, and falls back to the ground. When was it moving the slowest?

	Code	Count	Percentage
Correct	2	0	0%
Partially correct	1	91	29%
Incorrect/no answer	0	224	71%
		315	

Q2 Rocket 2 - Draw or explain your answer.

	Code	Count	Percentage
Correct	2	26	8%
Partially correct	1	21	7%
Incorrect/no answer	0	268	85%
		315	

Q3 Ball 1 - How are the pictures different?

	Code	Count	Percentage
Correct	2	103	33%
Partially correct	1	175	56%
Incorrect/no answer	0	37	12%
		315	

Q4 Ball 2 - Which is the "before" picture? Which is the "after" picture? Why?

	Code	Count	Percentage
Correct	2	78	25%
Partially correct	1	175	56%
Incorrect/no answer	0	62	20%
		315	

Q5 Wall 1 - Draw lines to show what happens when a baseball leaves your hand and hits a wall.

	Code	Count	Percentage
Correct	2	192	61%
Partially correct	1	54	17%
Incorrect/no answer	0	69	22%
		315	

Q6 Wall 2 - Explain your answer.

	Code	Count	Percentage
Correct	2	176	56%
Partially correct	1	36	11%
Incorrect/no answer	0	103	33%
		315	

Q7 After visiting COSI, I think science is:

	Code	Count	Percentage
More interesting than I thought before	M	209	66%
Less interesting than I thought before	L	15	5%
Just as interesting than I thought before	J	56	18%
(no answer)	X	32	10%
(all other responses)	other	3	1%
		315	

Q8 Visiting COSI made me feel that science is:

	Code	Count	Percentage
More fun than I thought before	M	201	64%
Less fun than I thought before	J	61	19%
Just as fun as I thought before	L	16	5%
(no answer)	X	33	10%
(all other responses)	other	4	1%
		315	

Q9 I think science is:

	Code	Count	Percentage
Interesting	I	210	67%
Boring	B	13	4%
O.K.	O	59	19%
(no answer)	X	33	10%
(all other responses)	other	0	0%
		315	

Q10 I think science class is:

	Code	Count	Percentage
Hard	H	66	21%
Easy	E	200	63%
(no answer)	X	32	10%
(all other responses)	other	17	5%
		315	